Chapter 3

UTILIZATION OF TiungSAT-1 DATA FOR COASTAL CURRENT STUDIES

Maged Marghany and Mohd. Lokman Hussien
Institute of Oceanography (INOS)
University College Science and Technology Malaysia

ABSTRACT

This study proposes a method for utilizing TiungSAT-1 data for coastal current studies. The Hopfield neural network has been used to model surface current movements. The study shows that the surface current movements modeled from Hopfield neural network are increased with an area of high intensity variation. The surface currents vectors range from 0.7 m/s to 1.4 m/s. It can be concluded that TiungSAT-1 data could be used for the detection of surface currents based on the intensity gradient variations that can be detected from the energy equation motion of neuron.

INTRODUCTION

The water circulation pattern along the coastal waters of Malacca Straits plays a great role in determining the best location for waste disposal and maritime transportation. The coastal waters studies such as current movements and their effects on the oil spill spreading have received a great deal of attention from scientists and researchers. This is because of the fact that the Malacca strait represents a navigation channel which links the South China Sea and the Indian Ocean.

There are a few studies which have been concerned with water movements in the Malacca straits (Wrytki 1961; Maged 2000; Maged and Genederen 2001). These studies confirm that the water movements in the Malacca Straits are dominated by tidal effects. In this paper, a Hopfield neural network is utilized to model surface currents from sequences of TiungSAT-1 images. This study has the following hypothesis; (i) TiungSAT-1 image can be utilized for water movement modeling (ii) A Hopfield neural network can be an appropriate method for the development of automatic and reliable operational systems for the measurement surface current velocities and directions from sequential TiungSAT-1 images. The main objective of this study was to examine a Hopfield neural network for detecting surface current patterns.

NEURAL NETWORK MODEL

In matching processes using the Hopfield neural network, identified features have to be mathematically compared to each other in order to build an energy function that is minimized. Therefore, objects selected are described using mathematical descriptors that are representative of the shape of features being described, giving similar values for similar features. In this study, the following feature descriptors are chosen: (1) Curvature of local curve element (c_i) obtained with the least square approximation to a parabolic curve form $y = cx^2$ (ii)Angle orientation of local curve and (iii) Position of center point of local curve element (x_i,y_j).

Let $a \in \{-1, 1\}^{Zn}$ be the image used to represent a neuron state. Initialize a with a known longshore image pattern. The weight of the sysnaptic connections $T \in (\mathrm{R}^{Zn})^{Zn}$ that control the intensity of surface current linked with the output e_i of neuron i to neuron j which is defined by

$$T_i(j) = \left\{ \sum_{k=1}^{K} e_j^k e_i^k \right\} \quad \text{if } i \neq j$$
$$T_i = \{0\} \quad \text{if } i = j \tag{1.0}$$

Let the output of neuron j be defined by

$$e_j = 0.5\left(1 + \tanh p_{0,j}\right) \tag{2.0}$$

where

$$p_j = \sum_{i=1}^{k} T_{i,j} e_j \tag{3.0}$$

The energy of network can be given as

$$E = -0.5 \sum_{i=1}^{k} \sum_{j=1}^{k} T_{i,j} e_j^k e_i^k \tag{4.0}$$

The movement pattern of a neuron can be represented as

$$de = \int_0^t E dt \tag{5.0}$$

The equation of motion of neuron is applied to sequential TiungSAT-1 images. The neuron network has been taken in two dimensions: raw and column directions. To match between the similar features of surface patterns, it is required that the two features are extracted from the same location. The Hopefield network is utilized to detect the similar pattern being translated by the energy function. Energy function represents the similarity between features and vectors close to each other i.e., they have the same length and direction which means smoothness (Emery et al., 1992). The Euler method can be used to minimize the energy function of equation of neuron motion as follows

$$e_{ij}(t + \Delta t) = e_{ij}(t) + \Delta t \left(\frac{de_{ij}(t)}{dt} \right) \tag{6.0}$$

RESULTS AND DISCUSSION

Figure 1 shows the results of the Hopfield neural network. The surface current vectors show a clear flow towards the north. In the middle of the Malacca straits the current vectors tend to flow in an elliptical profile. It seems that displacement can be seen along sharp intensity gradients (Figure 1). The vector current velocities range from 0.7 m/s to 1.4 m/s.

Comparison of raw TiungSAT-1 data and that tested by Hopfield network, shows that Hopfield network is best suited for binary image classifications.

Patterns were described as vectors. This information is absent in the original data. The neural network is able to identify the propagation direction of any patterns. This could be the reason why the surface current vectors have a

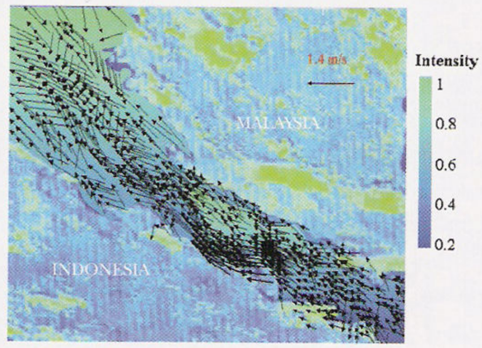
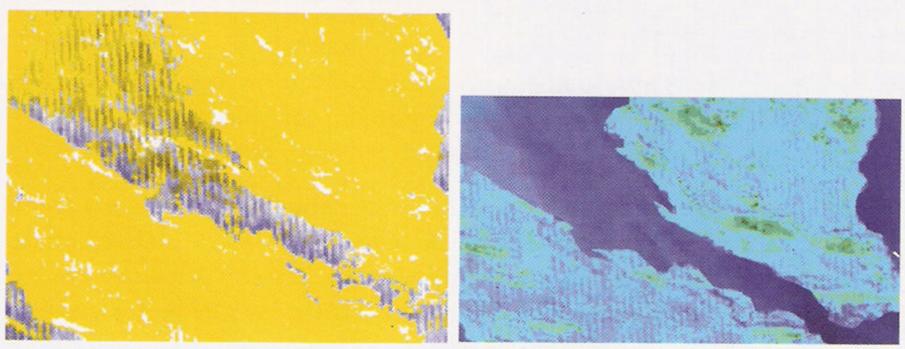


Figure 1. Hopfield Net Method Surface Current Vectors

direction. In addition, one of the common components of Hopfield network is the propagation rule. The propagation rule defines how surface current states and its synaptic strength combine as input to a neuron. It is clear that the original data has been corrupted by noise. The clear feature in Hopfield is that Hopfield network can be used for error correction by matching the corrupted image with the output pattern that it most resembles (Figure 2).

Figure 3 shows the tidal current components. North components are represented by V and the east components are represented by U. The V



(a) (b)

Figure 2. (a) Raw data (b) After the image was tested by Hopfield Neural Network

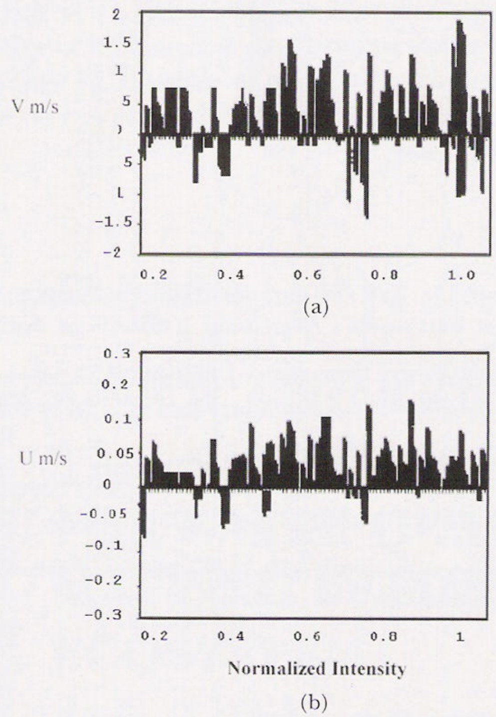


Figure 3. Current Components (a) V Components and (b) U Components

components move towards the north of the Malacca Straits with higher frequency intensity. The U components move towards the east with lower frequency intensity. This confirms the results in Figure 2. The Hopfield network can detect the current in areas of high intensity variations. These results confirm the study of Emery et al. (1992).

The current patterns detected from TiungSAT-1 data are similar to the studies by Wryki (1961), Maged (2000) and Maged and Genderen (2001). This indicates that the equation of energy motion applied with the TiungSAT-1 image is able to draw out the vector patterns and their components too. This could confirm previous studies which have applied the Hopfield network for modeling surface currents (Emery et al., 1993).

CONCLUSION

It can be concluded that TiungSAT-1 data can be utilized for coastal studies. This can be done by utilizing certain image processing such as the Hopfield network. The Hopfield network was able to correct the error in the original data. This induced a clear pattern for current movements in the Malacca Straits which could be detected or modeled by using the TiungSAT-1 data. The low resolution of TiungSAT-1 image enables only ocean surface current features to be studied on a large scale.

REFERENCES

Emery, W.J., m Fowler, C., and Clayson, C.A. 1992. *Satellite-image-Derived Gulf Stream Currents Compared with Numerical Model results.* J. Atm. Ocean Technology. 3: 286-304.

Maged, M. 2000. *Finite Element Simulation of Tidal Current Movements on Malacca Straits.* Proceeding of IGARSS' 2000. Honolulu, Hawaii 24-28 July 2000. Vol.II. p: 2966-2968.

Maged, M. and J. Genderen. 2001. *Texture algorithms for oil Pollution Detection and Tidal Current Effects on Oil Spill Spreading.* Asian J. Geoinformatics, 1, 33-44.

Wyrtki, K. 1961. *Physical Oceanography of the South-East Asian Waters.* In NAGA Report Vol. 2, Univ. Calif Scripps Inst. Ocean., La Jolla.